Dec. 14, 1971 E. S. ZOOK ET AL 3,626,733

TRUNCATED THROUGH FEED THREAD ROLLING DIE FOR ROLLING FLAT ROOTED THREADS

Filed March 26, 1969 3 Sheets-Sheet 1

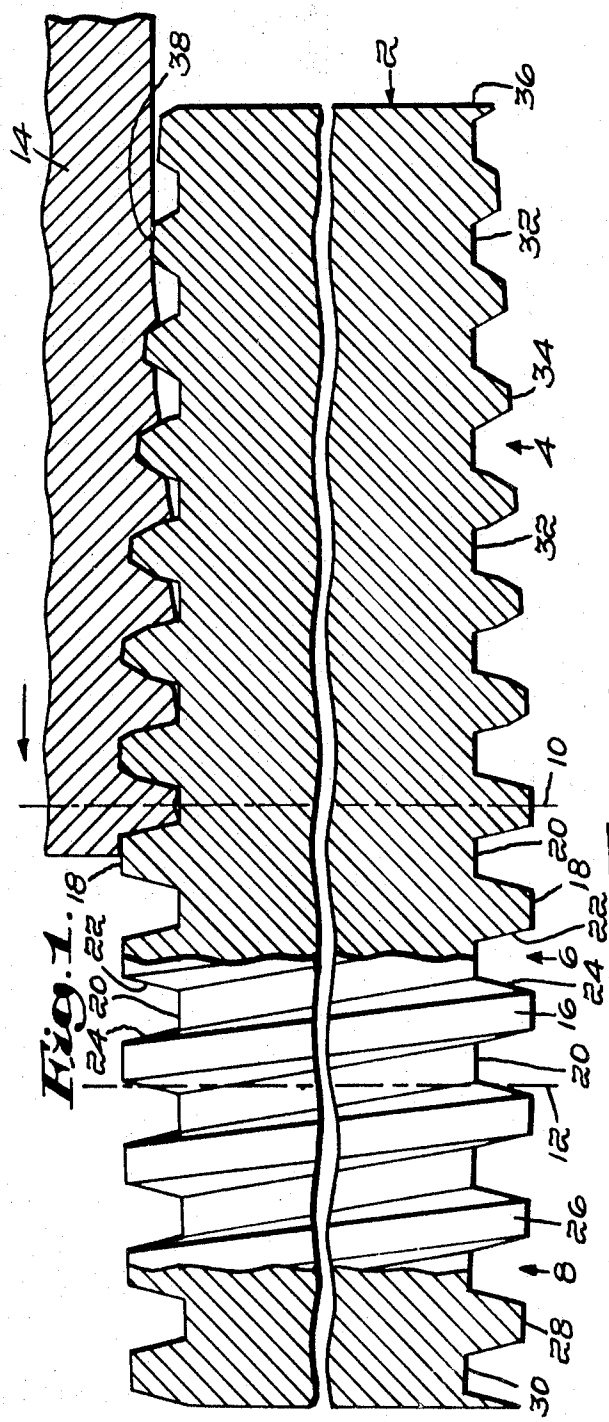



Fig. 1.

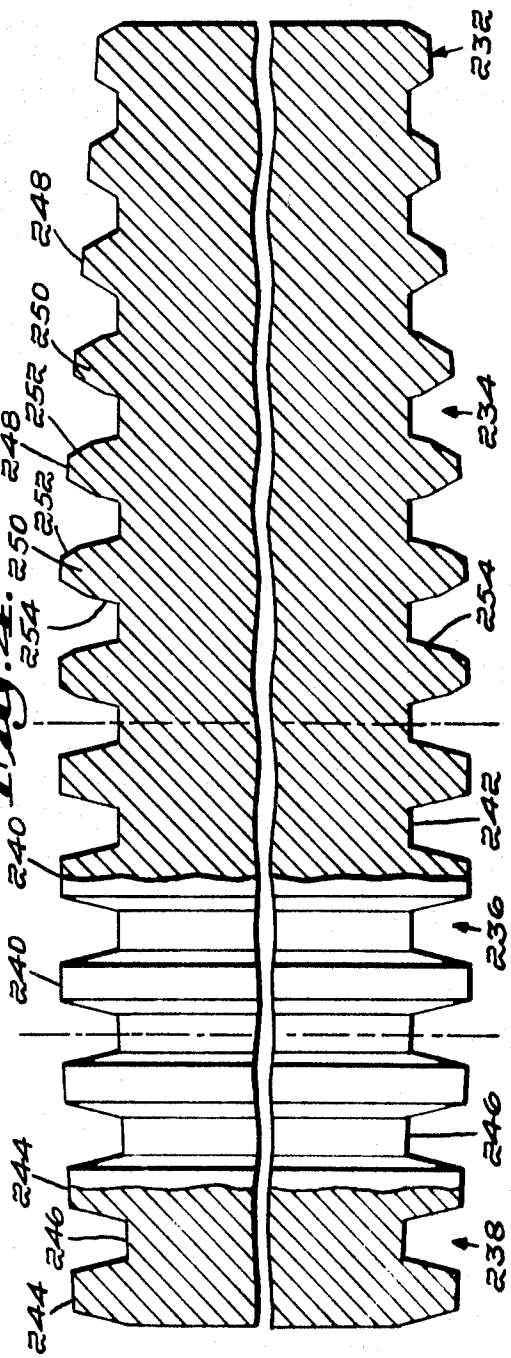



Fig. 4.

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TRUNCATED THROUGH FEED THREAD ROLLING DIE FOR ROLLING FLAT ROOTED THREADS

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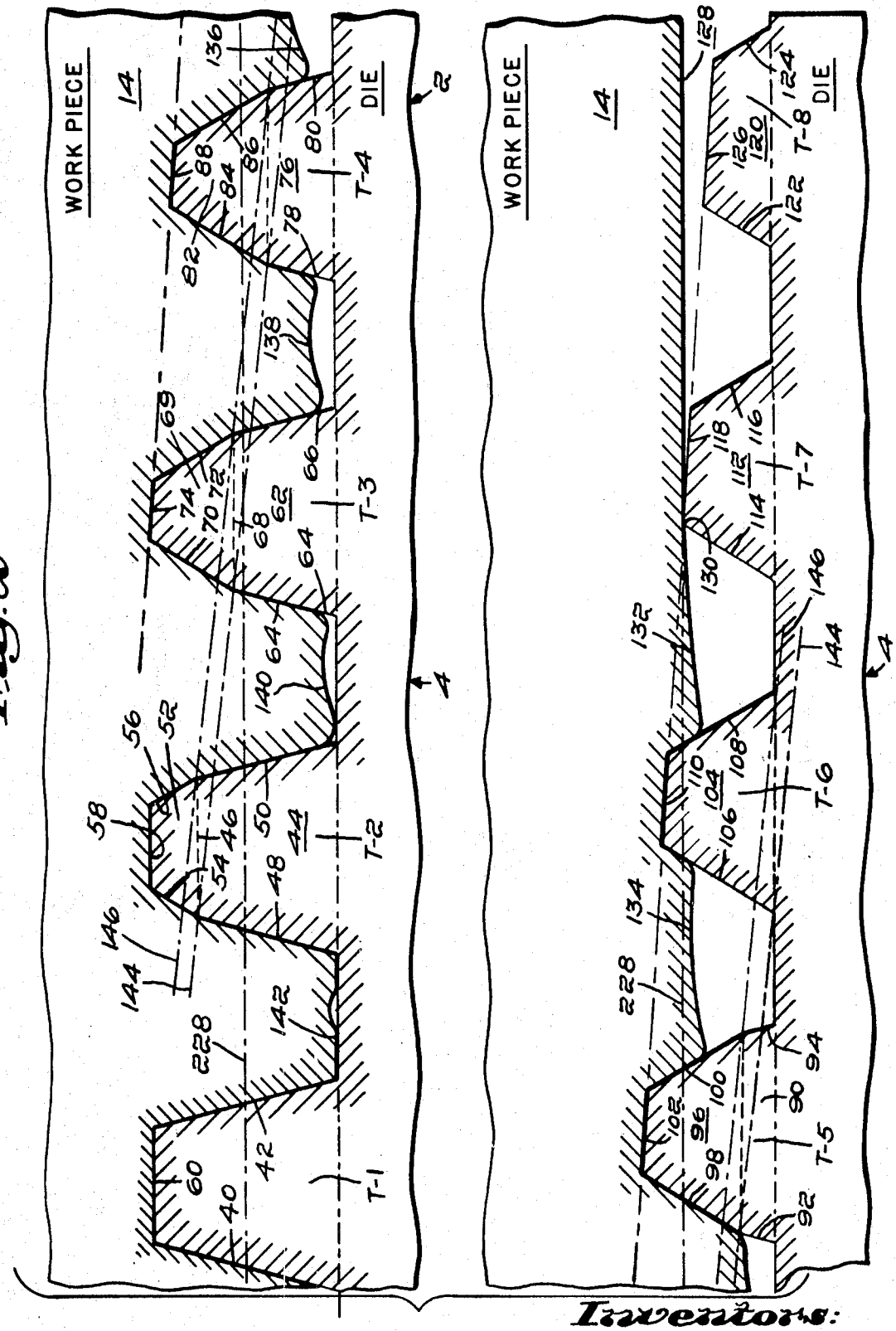



Fig. 2

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TRUNCATED THROUGH FEED THREAD ROLLING DIE FOR ROLLING FLAT ROOTED THREADS

Filed March 26, 1969 3 Sheets-Sheet 3

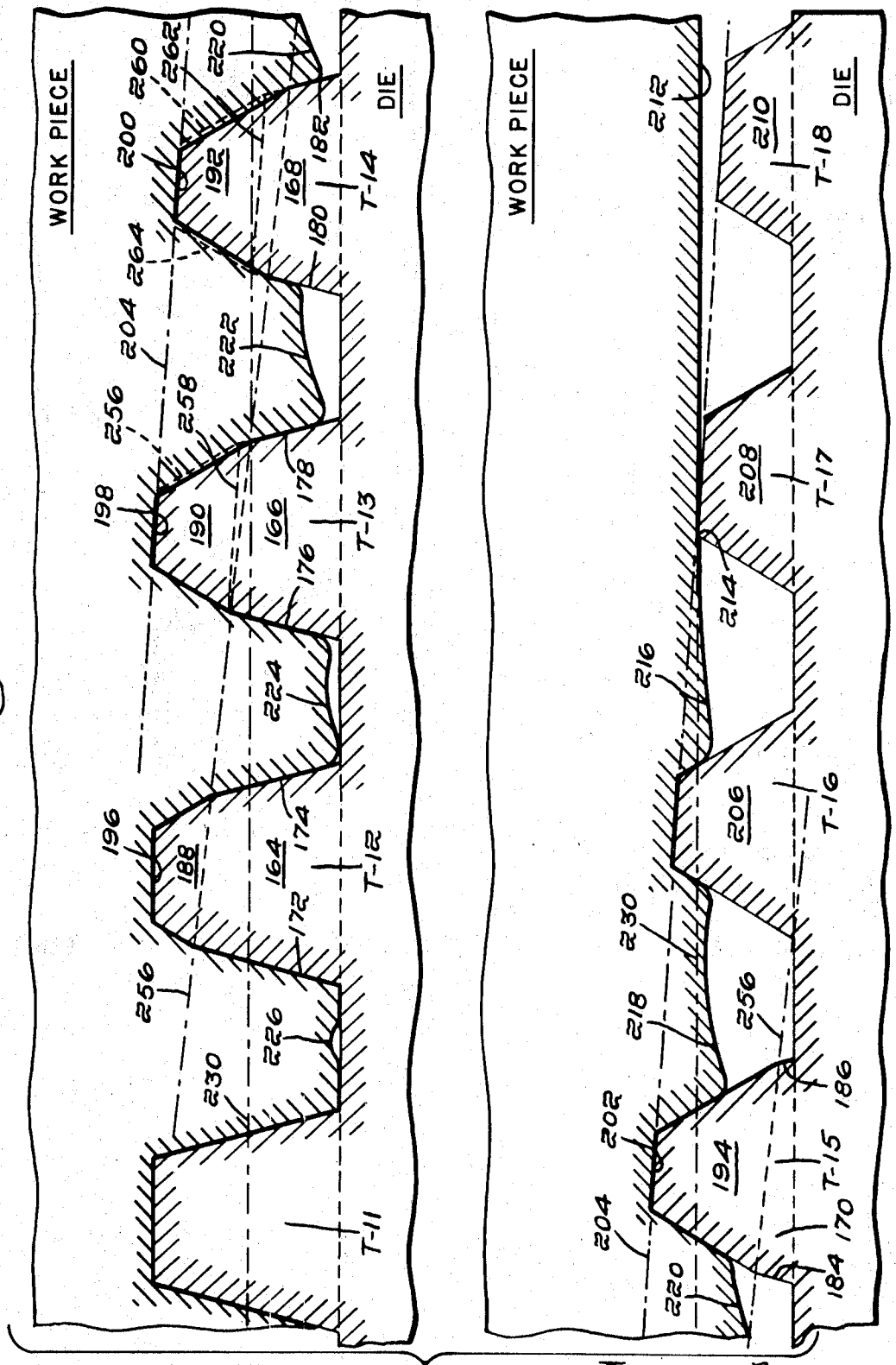



Fig. 3.

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United States Patent Office 3,626,733 Patented Dec. 14, 1971



3,626,733

# TRUNCATED THROUGH FEED THREAD ROLLING DIE FOR ROLLING FLAT ROOTED THREADS

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U.S. Cl. 72—104 21 Claims

## ABSTRACT OF THE DISCLOSURE

A through feed thread rolling die which acting in cooperation with one or more identical dies will produce so called Acme or similar threads on a work piece. The threads on the relieved starting section in which the root diameter is constant have a novel constantly changing cross section. The crests of the threads considered in longitudinal section are flat and lie in the surface of a truncated cone. The flanks of the threads that first contact the work are at a relatively wide angle so that good starting thread formation is produced in the work. As the thread on the die increases in diameter, the flanks assume a dual angularity with the wide angled flanks merging with steep inner flanks. When the tapered starting relief section reaches the full diameter intermediate dwell section, the wide angled flanks will have gradually disappeared to be replaced by the steep flanks of Acme configuration.

## BACKGROUND OF THE INVENTION

This invention relates to thread rolling dies for producing so called Acme or similar threads on work pieces which are passed through a cluster of such dies (two or more) while the dies are rotating in unison to produce a surface metal flow in the work piece, whereby a continuous Acme thread configuration is formed.

It is conventional practice to have a tapered entry section on thread rolling dies so that a converging opening is provided between the dies to permit the work piece to enter the cluster. The die threads on the starting section after initial contact enter progressively deeper into the work piece. The displaced metal rises in the space between the die threads so that the finished thread on the work piece will have a mean diameter equal to the initial work piece diameter.

The prior art devices for rolling wide, flat rooted threads of the Acme type provide a tapered starting section having flat rooted threads which taper at the root diameter. The tapered starting thread turns have pointed crests as distinguished from flat crests. These pointed crests in the tapered starting section change to flat crests of increasing width as the dwell section is approached. The bottom portion of each thread flank slopes approximately at the flank angle of the finished Acme thread and the top portion is at a greater flank angle. In the prior art construction just referred to, the height of the bottom flank portion increases and the height of the top flank portion decreases as the thread turns progress away from the starting end.

While it has been the generally accepted practice to start the threads in the work piece with a sharp crest on the die thread, it is also known that this results in frequent misalignment of the work relative to the axial path through the die cluster and causes what are commonly referred to as "drunken threads."

Attempts to initiate metal flow with flat creasted, fully formed die threads of Acme or similar configuration with the crests and roots uniformly tapered in the starting section have been unsatisfactory because the surface



metal of the work piece is necessarily forced at once laterally and outwardly in a manner that prevents proper following of the steep thread flanks. This acute metal compression and improper extrusion weakens the finished thread and produces a "foiling" effect wherein the metal at the surface of the finished thread peels off in foil-like layers.

## SUMMARY OF THE INVENTION

In accordance with our invention, a thread rolling die for rolling flat rooted threads is adapted to be rotatably supported in a cluster of normally two or three rolls with the roll axes either parallel to or skewed from the axis of the work. The starting section of the die roll has a plurality of thread turns of constant root diameter. These thread turns have relatively wide flat crests uniformly tapered with respect to the roll axis to permit precise alignment of the work axis with the pass line of the die cluster. This flat sloping crest configuration substantially eliminates the misalignment problems that heretofore have produced undesirable "drunken threads." The initial thread turns in the starting section have single flanks for starting the work piece thread. Thereafter, the thread turns are provided with double sloped flanks. The single flanks of the thread turns initially contacting the work have a flank angle which is greater than the flank angle of the finished thread, preferably a 60° included angle. This enables the surface metal of the work piece to flow laterally and then outwardly along the wide angled flanks toward the die root without undue stress.

The starting section threads progressively remote from the starting end increase uniformly in height and develop a lower flank portion in which the flanks slope at the finished thread flank angle, which is normally an included angle of 29° for the Acme thread. The upper wide angled flanks are still present but of diminishing height. The height of the lower steep flank increases as the height of the wide angled flanks decreases so that the metal of the work piece flows first over the wide angled upper flanks and then into the space between the developing lower steep flanks, whereby the finished thread is gradually built up by an extrusion action which eliminates the tendency to "foil."

The principal object of our invention is, accordingly, to provide a through-feed thread rolling die for rolling Acme type and similar wide, flat rooted steep flanked threads. Such threads can be produced by using a cluster of two or more identical dies each having an axis of rotation either parallel to or uniformly skewed from the pass line of the work through the cluster. Our dies have an improved starting thread configuration which permits accurate initial alignment of the work and improved metal deformation of the work to produce mechanically sound threads that do not tend to peel or "foil."

In the simplified construction, the die will carry a single continuous thread, but other thread forms may be used according to the thread requirements of the work piece without in any way changing the nature of the invention. For example, double continuous threads might be utilized. Or, the threads might be annular rather than helical, in which case the die axes would be skewed with respect to the work axis.

## DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view partially in section and broken longitudinally of a thread rolling die having a helical thread made in accordance with our invention and shown in relation to an incoming workpiece.

FIG. 2 is an enlarged detailed view of the die construction and work piece showing in better detail the nature of the die threads in the starting section and the development of the threads in the work piece.

FIG. 3 is a modification of the die thread construction in the starting section.

FIG. 4 is a view similar to FIG. 1 showing the invention when applied to annular threads.

## DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, a thread rolling die generally indicated at **2** is shown in the form of a roll with an external helical Acme thread formed thereon. The roll **2** may be any desired diameter and is adapted to be driven in a cluster of two or more rolls spaced to form a pass line between the rolls which is correct for the size of the work to be threaded. In this embodiment of the invention a single Acme thread is developed on the surface of the roll **2** consisting of a plurality of turns in the form of a continuous helix over the central or dwell portion of the die. Depending upon the diameter of the dies in relation to the work, multiple helical thread configurations may also be employed. For simplicity of illustration, however, the invention is illustrated with respect to a single continuous helical thread configuration, as well as to an annular thread configuration as illustrated in FIG. 4.

The roll or die **2** comprises a starting relief section **4**, a dwell section **6** and a finish relief section **8**. The points of transition between the sections **4**, **6** and **8** are indicated approximately by dot and dash lines **10** and **12** in FIG. 1. Also shown in FIG. 1 is the leading end of a portion of a work piece **14** which is progressing through a set of rolls with rolling forces applied by the rolls to the work piece such that the desired thread formation is rolled into the metal surface of the work piece. It will be understood that the rolling operation takes place with each die **2** rotating about its axis, which, according to the nature of the threads, may or may not be parallel to the direction of motion of the work piece **14** indicated by the arrow in FIG. 1. The roll axis about which the die **2** rotates is also taken as the axis of reference for the angles of the various portions of the helical thread on the surface of the die **2** hereinafter described.

The dwell section **6** of the die **2** is provided with a full sized Acme thread **16** having flat crests **18** and flat roots **20** which correspond in size and pitch to the desired finished thread formation for the work piece **14**. The thread walls or flanks **22** and **24** in accord with Acme thread design form an included angle therebetween of 29°. The length of the dwell section **6** includes a plurality of complete thread turns and operates in a known manner to finish the thread rolled onto the work piece into the final desired size and tolerance dimension.

The envelope of the crests **18** is cylindrical and parallel to the axis of rotation of the roll **2** and the envelope of the roots **20** is also cylindrical and parallel to the axis of rotation of the roll **2**. Thus the dwell section serves to finish form the threads on the work piece **14** with the desired thread configuration having roots and crests that are uniformly distant from the axis of the work piece **14**. The thread formed on the work piece will correspond in cross section to the thread **16** of the die.

The finish relief section **8** has a plurality of full size thread turns **26** having crests **28** and roots **30** but differs from the dwell section **6** in that the envelope of the roots **30** is conical and tapers towards the axis of rotation of the roll **2**. Similarly, the envelope of the crests **28** is also conical and tapers towards the axis of the roll **2**. These two conical envelopes are parallel and coaxial. Thus, with respect to the work which passes through the set of dies, the threads **26** of the tapered finish relief section **8** move gradually away from the corresponding roots, crests and flanks of the finished thread on the work piece. The gradual changes in pressure of the dies against the work piece as the latter moves from the dwell section **6** to the finish relief section **7** insures that the thread surfaces will leave the dies in commercially acceptable condition.

The starting relief section **4**, in accordance with the present invention, provides generally a continuation of the threads from the dwell section **6** with flat roots **32** for all thread turns from the dot and dash line **10** to the starting end of the die. The roots **32** in the starting relief section **4** are spaced equidistant from the axis of rotation of the roll **2**. Thus the envelopes of the roots **32** of the starting section and the roots **20** of the dwell section are cylindrical and of the same diameter and their axes coincide with the axis of rotation of the roll **2**. The pitch of the threads in the starting relief section **4** is the same as the pitch of the threads in the dwell section **6**.

The crests **34** of the threads in the starting relief section **4** are flat in longitudinal section and taper at a small angle relative to the axis of rotation of the roll **2**. The flat surfaces of the crests **34** coincide with the conical crest envelope and thus the general shape of the starting relief section is simply a uniformly tapered portion with threads of decreasing height from the dwell section **6** to the starting end of the die. The angle and extent of the crest taper is such that the entry end **36** of the die has a diameter which, when mounted in a cluster, provides an entrance of greater diameter than the diameter of the work **14** as it enters the dies. Thus the crests **34** contact the work piece at some intermediate point suggested at **38** on the tapered surface of the starting relief section **4** and, as contact is made, the internal metal flow in the work **14** is initiated.

Referring now to FIG. 2, there is shown in greatly enlarged detail the nature of the thread construction in the starting relief section **4** which constitutes the invention. For purposes of easy reference, the individual threads have been indicated as T–**1**, T–**2**, T–**3**, T–**4**, T–**5**, T–**6**, T–**7** and T–**8**. Thread T–**1** is the first thread in the dwell section and is a fully formed Acme thread having flanks **40** and **42** which converge at the conventional Acme angle of 29°.

Thread T–**2** may be described as comprised of two superimposed trapezoids. The lower trapezoid **44** culminates at the dot and dash line **46** and has its flanks **48** and **50** converging at 29°. The upper trapezoid **52** has a bottom side which coincides with the upper side of trapezoid **44** along the line **46**. The flanks **54** and **56** converge at an angle of 60°. The crest **58** is at the same radius as the crest **60** of thread T–**1**. Crest **58** is shown as parallel to the die axis, but it is to be understood that the tapering of the crests can commence at any selected thread. For example, the tapering of crests could commence at T–**1** before the commencement of the generation of the wide angled flanks first appearing in T–**2** at **54** and **56**.

In thread T–**3**, the lower part of the thread is in the form of a trapezoid **62** with flanks **64** and **66** converging at the 29° angle. On the upper side **68** of trapezoid **62** is the trapezium **69** having the flanks **70** and **72** converging at 60°, and having a crest **74** which slopes at a small angle toward the die axis. It will be appreciated that the crest **58** blends into crest **74** during one turn of the thread from T–**2** to T–**3**.

Thread T–**4** has its lower part in the form of the trapezoid **76** with flanks **78** and **80** covering at 29° and above is a trapezium **82** with flanks **84** and **86** converging at 60°. The upper crest **88** slopes toward the die axis and preferably is aligned with crest **74** of thread T–**3**.

In thread T–**5** the lower portion of the thread is in the form of a trapezoid **90** having flanks **92** and **94** which converge at 29° and above trapezoid **90** is a trapezium **96** having flanks **98** and **100** which converge at 60°. The top of trapezium **96** is the crest **102** which is aligned with crests **74** and **88**.

It should be noted at this point that the trapezoid thread portions **44**, **62**, **76** and **90** are all of the same pitch as the threads in the dwell section **6**, but these portions are progressively of less height and correspondingly of less area. On the other hand, the trapeziums **52**, **69**, **82** and **96** are of progressively increasing area and the crests **74**, **88** and **102** are of approximately the same width which width is determined by the taper of the conical envelope in which the crests **74**, **88** and **102** reside.

Coming now to threads T–6, T–7 and T–8, it will be noticed that the lower trapezoidal portion present in threads T–1 to T–5 has now disappeared. Thread T–6 is comprised solely of a trapezium **104** having flanks **106** and **108** and a crest **110** which is aligned with crests **74**, **88** and **102** and is of slightly greater width than crest **102**.

Thread T–7 is in the form of a trapezium **112** having flanks **114**, **116** and a crest **118**, which crest is still wider than crest **110**.

The final thread T–8 is in the form of a trapezium **120** having flanks **122** and **124** and a crest **126**, which crest likewise is aligned with all of the other crests, but wider than crest **118**.

The flanks of threads T–6, T–7 and T–8 all converge at an agle of 60°. The cross-sectional areas of trapeziums **104**, **112** and **120** are of decreasing order.

The line **128** represents the outside periphery of the cylindrical work piece **14** that is being fed into the dies. It will be noticed that in FIG. 2 the work is initially engaged by the corner **130** of thread T–7. Thereafter, as the work moves forward to thread T–6, the die will progressively force its way into the metal of the work piece **14** causing the metal to flow along the 60° sides of the threads T–7, T–6 and T–5 to produce approximate formations such as indicated at **132** and **134**. By the time the work piece has reached thread T–4, the metal will have been extruded to approximately the position **136**, at which point the Acme type flanks sloping at a converging angle of 29° begin to come into play. The initial outward displacement of the metal of the work piece has been caused by the crests and 60° flanks of the trapeziums **112**, **104** and **96** which makes it much easier for the extruded metal to move outwardly between the more steeply sloping flanks as illustrated by the thread formation **138** developing between flanks **78** and **66** of threads T–4, T–3.

As the steep flanks of the lower trapezoids **90**, **76**, **62** and **44** continue to increase in height as illustrated by flanks **94**, **92**, **80**, **78**, **66**, **64**, **50** and **48**, the metal of the work piece, having initially been displaced by the 60° flanks of the upper trapeziums, flows far more readily into the space between the steeply sloping flanks as indicated at **140** and finally **142** at which point the Acme thread is substantially complete and is then finished by the threads T–1 and the succession of identical threads throughout the extent of the dwell section **6**.

From the foregoing explanation, the following important features will be noted. All of the threads T–1 to T–8, inclusive, are of the same pitch but starting with thread T–3 of decreasing radius. The flat crests from T–3 to T–8 all slope preferably in alignment as illustrated toward the die axis. The deformation of the work piece throughout the starting relief section **4** is initiated by threads which have flanks converging at 60° and flat crests. The starting threads T–7, T–6 and T–5 facilitate alignment of the work axis with the dies and minimize the tendency to develop so-called "drunken threads." Thereafter, the outer portions of the developing threads are more readily forced outwardly between the steeper sloping flanks **92–80**, **78–66**, **64–50**, and **48–42** without damage to the outer periphery of the work piece thread structure.

The development of the thread on the starting relief section of the die is readily accomplished. The full sized Acme thread is machined or ground throughout the length of the starting relief section and the dwell section. With this accomplished, the crests of threads T–3, T–4, T–5, T–6, T–7 and T–8 may be finished to a selected taper (preferably between 1½° and 5° but not over 12°) to produce the sloping crests **74**, **88**, **102**, **110**, **118** and **126**. Thereafter, the 60° flanks may be machined or ground to the pattern disclosed in FIG. 2.

The dot and dash lines **144** and **146** are included to illustrate one way in which the changing dimensions of the die threads may be developed. The angle of these lines to the die axis may be varied. If of less slope, there will be more threads in the starting relief section having the dual sloping flanks which would make metal movement in the work piece more gradual. Conversely, if the slope of the lines **144** and **146** is at a greater angle to the axis, then the starting threads will increase in height at a greater rate with a corresponding increase in the rate of the work piece deformation.

In FIG. 3 is shown a thread construction which performs substantially in the same manner as that shown in FIG. 2. The cross-sectional configuration of each of the threads T–12, T–13, T–14 and T–15 (corresponding generally to threads T–2 and 2–5 in FIG. 2) is modified slightly, but the construction of the threads T–16, T–17 and T–18 is identical with the construction of threads T–6, T–7 and T–8 in FIG. 2. In FIG. 3 the lower portions of threads **164**, **166**, **168** and **170** are in the form of trapeziums instead of trapezoids. Thus the flanks **172** and **174** are not of equal length as in the case of flanks **48** and **50** of the thread T–2. The same comment applies with respect to flanks **176** and **178**, **180** and **182**, and **184** and **186**. The flanks just mentioned slope toward each other at 29° if an Acme thread is to be formed on the work piece.

The upper portions of the threads T–12, T–13, T–14 and T–15 are in the form of trapeziums **188**, **190**, **192** and **194**. These trapeziums have their flanks sloping toward each other at an angle of 60°, the same as in the case of the upper trapeziums in FIG. 2. Crest **96** of thread T–12 is parallel to the die axis. The crests **198**, **200** and **202** slope toward the axis of the die along a line **204** running at an angle which intersects trapeziums **190**, **192** and **194** to produce crests of equal length.

The threads T–16, T–17 and T–18 are single trapeziums indicated at **206**, **208** and **210** with their flanks intersecting at an angle of 60°.

The line **212** represents the periphery of the cylindrical work piece and as it advances into the die of FIG. 3, it is first engaged by thread T–17 at **214** and then progressively by threads T–16, T–15, T–14, T–13 and T–12. The 60° sloping flanks which initially encounter the work piece, accurately start the extrusion of the metal in a manner causing no damage to the thread through all of its development.

The development of the thread in the work piece is shown by consideration of the lines **216**, **218**, **220**, **222**, **224** and **226** which illustrate how the metal of the work piece progresses from its initial displacement by the 60° flanks to its final flowing into Acme form between the 29° flanks of threads T–14, T–13, T–12 and T–11.

The behavior of the developing thread in the work piece in either of the constructions shown in FIG. 2 and FIG. 3 is substantially the same. As previously mentioned, the major features of the invention are the sloping flat crests, the 60° thread walls that initially act on the work piece to force the metal to a position where it is readily received by the steep flanks having the included angle of 29°.

When the thread is finished, the amount of metal displaced in the work piece by the upper part of die thread T–1 in FIG. 2 or T–11 in FIG. 3 above the pitch line **228** in FIG. 2 or **230** in FIG. 3 will be substantially equal to the amount of metal in the work piece below line **228** or **230**. Thus, as the work piece progresses through the dwell section **6** in which the threads **16** are identical with the threads T–1 and T–11 in FIGS. 2 and 3, there will occur a burnishing and finishing effect on the fully formed work piece threads so that when the work piece is discharged from the finish relief section **8**, the threads will be in commercially acceptable condition.

Turning now to FIG. 4, an Acme thread rolling die according to an alternate embodiment of the invention is there shown in the form of a roll with annular threads as distinguished from the helical thread of FIGS. 1, 2 and 3. A die **232** comprises a starting relief section **234**, a dwell section **236**, and a finish relief section **238**, which

sections are substantially identical to sections **4**, **6** and **8** of the embodiment shown in FIGS. 1, except, as just noted, the thread is not continuous but annular. Thus the envelopes of dwell section crests **240** and roots **242** are cylindrical and parallel to the axis of the die **232**; the envelopes of the finish relief section crests **244** and root **246** are conical and taper toward the axis of the roll **232**; the envelope of the roots of the starting relief section **234** is an extension of the dwell section root envelope and is cylindrical and parallel to the roll axis. Starting relief section crests **240** are flat in longitudinal section and taper at a small angle with respect to the die axis. The starting relief thread turns **250** have the flanks **252** of the upper portions at a wide angle (for example 60°) and finished thread flank lower portions **254** substantially identical to the individual thread constructions T–1 to T–8 in FIG. 2, and T–11 to T–18 in FIG. 3 discussed above.

In operation a cluster of the rolls **2** or **232** are suitably spaced and rotatably mounted and driven about the pass line of the work piece. The work piece is fed into the die cluster within the confines of the tapered starting threads. The flat crested wide angled threads grip the work causing the thread to be gradually and fully formed by the time the dwell section is reached. Thereafter, finishing and relief takes place.

The die according to the embodiment of FIG. 4 may be manufactured by forming a uniform Acme thread in annular form having a constant root depth and constant root radius from the roll axis on the starting relief section **234** and the dwell section **236** by conventional techniques. The starting relief section **234** may then be uniformly tapered by machining or grinding the crests **248** at a selected small angle which is preferably between 1½° and 5°, and, in any event, is not over 12°. The flanks of the starting relief section threads **250** may then be machined or ground to produce the wide angled upper portions **252**. The lower portions **254** are unchanged from the Acme thread configuration. Wide, flat rooted thread forms other than the Acme thread illustrated can, of course, be produced with dies manufactured in accordance with our invention by forming worm, drive screw or similar threads on the die with the threads in the starting relief section having flat tapered crests and having at the outer portions wide angled flanks which intersect steeper inner flanks along an increasing radical distance as the dwell section is approached.

With respect to the tapered crests running from the dwell section to the starting end of the starting section, it is to be understood that the thread turn at which the tapering of the crests commences may or may not be the same thread turn where the wide angled flanks start to be generated. The movement of the metal of the work piece to completed thread form when the dwell section is reached, is not affected in any way by the limited angular variation in the starting positions of the sloping crests and wide angled flanks.

In the claims, the broad word trapezium is used. This includes trapezoids. The lower trapezium might be a trapezoid as in FIG. 2, or not as in FIG. 3. Likewise, the upper trapezium might or might not be a trapezoid according to the designer's preference. The dotted lines **256** and **258** inserted in FIG. 3 at the top of thread T–13, and the dotted lines **260**, **262** and **264** inserted at the top of thread T–14 show how the upper part could be in trapezoidal form while leaving the lower portion as a trapezium.

In the light of the above explanation of the invention, other modifications within the scope of the claims will readily suggest themselves to those skilled in the art.

We claim:

**1.** A through feed thread rolling die for creating wide, flat rooted steep flanked threads by surface metal flow in a cylindrical workpiece comprising a roll die formed with an external flat rooted thread having a starting section, a dwell section and a finish relief section; said dwell section having a fully formed flat rooted thread of uniform dimensions throughout its length; the thread in said starting and dwell sections having a common cylindrical root envelope whose axis coincides with the axis of said roll; the thread in said starting section being relieved and comprising a plurality of thread turns with flat crests that form a constant predetermined angle with the roll axis, said relieved thread having at the starting end a crest height below the mean height of the threads in said dwell section; said starting section thread turns comprising an upper portion the flanks of which slope toward each other at a flank angle greater than the flank angle of the threads in said dwell section, and a lower portion the flanks of which slope at the flank angle of said dwell section; the lengths of the flanks of said upper portion gradually decreasing in thread turns progressively remote from said starting section end, the lengths of the flanks of said lower portion gradually increasing in thread turns progressively remote from said starting section end; and said finish section having threads tapering to a reduced diameter thereby to provide adequate relief for a completed thread on the work piece as it leaves said dwell section.

**2.** A through feed thread rolling die as set forth in claim **1** in which said starting section thread crests have progressively increasing diameters as they approach said dwell section, the envelope of said starting section thread crests defining a truncated cone in which the apex angle of said cone is not greater than 12°.

**3.** A through feed thread rolling die as set forth in claim **1**, in which the envelopes of the roots and crests of the threads of said finish relief section define two spaced truncated cones whose walls are substantially parallel.

**4.** A through feed thread rolling die as set forth in claim **2** in which said angle of said starting section flat crests is the same as the angle of said envelope of said starting section thread crests thereby locating the full width of said flat crests on said envelope.

**5.** A through feed thread rolling die as set forth in claim **1** in which said upper starting thread turn portion flank angle is approximately 60° to said die axis.

**6.** A through feed thread rolling die as set forth in claim **1** in which the flank angle of the said lower portion is approximately 75½° to said die axis.

**7.** A through feed thread rolling die as set forth in claim **1** in which said external thread comprises at least one continuous helical thread.

**8.** A through feed thread rolling die as set forth in claim **1** in which said external thread comprises a plurality of annular thread turns.

**9.** A through feed thread rolling die for creating in a cylindrical work piece by surface metal flow threads of the type having wide roots and steep flanks, said die comprised of a starting section, a dwell section and a finish relief section, the thread in said dwell section being complementary to the finished thread in said work piece, the thread in said starting section being formed as follows: the pitch of the thread is the same as that in the dwell section; the width and radius of the root is the same as that in the dwell section; in the thread turns of the starting section adjacent the dwell section, there are first flank portions which lead outwardly away from the root, the said first flank portions being of the same angularity as the flanks in the dwell section but becoming progressively of less height as the thread moves from the dwell section toward the starting end of the die until the said first flank portions disappear when the upper edge of each said first flank portion reaches the root; second flank portions on each thread turn extending outwardly from said first flank portions and having a substantially less steep slope than the said first flank portions and terminating at a flat crest; a

majority, at least, of all adjacent said flat crests sloping uniformly toward the die axis, the height of said second flank portions becoming constantly greater as the thread moves from the dwell section toward the starting end until the inner edges of said second flank portions meet the said root at the thread position where the said first flank portions disappeared; the thread height at the starting end of said die being less than the mean height of the thread in said dwell section; misalignment of the work piece when the dies are arranged in a cluster, the metal in said work piece is initially engaged by one of said sloping flat crests and is progressively extruded between said second flank portions as the work advances along the thread of the said starting section and whereby the flow of metal into the space between said first flank portions does not occur until the thread formation in the work piece is sufficiently developed by said second flank portions to preclude subsequent misalignment of the work piece.

**10.** A through feed thread rolling die for creating in a cylindrical work piece by surface metal flow, threads of the type having wide roots, steep flanks and wide crests, said die comprised of a starting section, a dwell section and a finish relief section, the threads in the starting section being of the same pitch and root diameter as the threads in the dwell section, each thread in the starting section in cross section for a predetermined number of consecutive threads away from the dwell section toward the starting end of said starting section being comprised of a lower trapezium and an upper trapezium set one on the other, the lower trapeziums having the same base width and having upwardly extending flanks converging at the same angle, said lower trapeziums decreasing in height and cross sectional area as the thread progresses toward the starting end, the bottom sides of the upper trapeziums fitting on the top sides of the lower trapeziums and having flanks converging at an angle which is greater than the converging angle of the flanks of the lower trapeziums, said upper trapeziums as the thread progresses in the direction of the starting end of said starting section increasing in width and in cross sectional area, the upper side of each of said upper trapeziums forming a flat crest, a consecutive plurality of said flat crests sloping toward the axis of said die, and additional continuing threads at the starting end of said die each of which in cross section is in the form of a single trapezium having a flat crest and flanks generally parallel to the flanks of said upper trapezium.

**11.** The die set forth in claim **10** in which said crests in the starting section are in alignment and reside in the surface of a cone whose axis coincides with the axis of said die.

**12.** The die set forth in claim **10** in which said sloping crests which engage the work piece are of less width than the crests of the threads in said dwell section.

**13.** The die set forth in claim **10** the cross sectional area of each said additional thread decreasing as the starting end of the die is approached.

**14.** The die set forth in claim **10** in which the flanks of the lower trapeziums are at an included angle of 29° and the flanks of the upper trapeziums are at an included angle of 60°.

**15.** The die set forth in claim **10** in which said crests of said additional threads are of increasing width.

**16.** The die set forth in claim **10** in which the lower trapeziums are in the form of trapezoids.

**17.** The die set forth in claim **10** in which a consecutive number of the upper trapeziums are in the form of trapezoids.

**18.** A through feed thread rolling die for creating in a cylindrical work piece by surface metal flow, threads of the type having wide roots, steep flanks and wide crests; said die comprising a relieved starting section; a dwell section and a finish relief section; the threads in said starting section being of progressively increasing outer diameter and of constant root diameter from the starting end to said dwell section; the threads in said dwell section being of constant maximum finished thread dimensions and having the same root diameter as in the starting section; the first thread in said starting section being of less outer diameter than the mean diameter of the threads in said dwell section; the first threads in said starting section having flat sloping crests from which extend wide angled flanks which terminate at the said constant root diameter; subsequent threads between said first threads and the threads in said dwell section having flat sloping crests from which extend wide angled flanks of constantly changing dimensions which terminate at the upper ends of steeper flanks of constantly changing dimensions extending outward from said root.

**19.** The die structure set forth in claim **18** in which the said wide angled flanks are at an angle of approximately 60° to said root line and the said steeper flanks are at an angle of approximately 75½° to said root line.

**20.** The die structure set forth in claim **18** in which said subsequent threads in cross section comprise upper and lower trapeziums positioned one on the other, with the top side of the lower trapezium constituting the bottom side of the upper trapezium.

**21.** A through feed thread rolling die for rolling in a cylindrical work piece by surface metal flow, threads of the type having wide roots, steep flanks and wide crests, said die comprising a starting section and a dwell section, the root diameter and pitch of the threads in both sections being the same, the threads in the dwell section being of full size with steeply sloping flanks and flat crests paralleling the die axis and lying in a cylindrical envelope, the threads in the starting section having flat crests which taper outwardly from a diameter at the starting end that is less than the mean diameter of the threads in the dwell section to a maximum diameter to meet and blend into the first full diameter crest of the dwell section, the first threads at the starting end being in cross section in the form of trapeziums, the subsequent threads as they develop between the said first threads and the threads in the dwell section being in cross section in the form of two trapeziums one above the other, the lower trapezium having steeply sloping flanks and increasing in cross sectional area and the upper trapezium having relatively wide angled flanks and decreasing in cross sectional area as the thread of the starting section approaches the dwell section.

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# UNITED STATES PATENT OFFICE
# CERTIFICATE OF CORRECTION

Patent No. 3,626,733 Dated December 14, 1971

Inventor(s) Elmer S. Zook and Paul W. Ronn

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 3, Line 72: "7" should be --8--.

Col. 6, Line 12: "2-5" should be --T-5--.

Col. 7, Line 11: "240" should be --248--.

Col. 9, Claim 9, Line 9: ";" should be --.--.

Col. 9, Claim 9, Line 9: "misalignment of the work piece when the dies are arranged, etc., etc. to the end of Claim 9" should be deleted from the printed patent. See our Paper No. 5, dated 6/28/71 requesting cancellation of this portion of Claim 9.

Signed and sealed this 6th day of June 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

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